

VIRTUAL HISTOLOGY in AMI

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Clinical Progression of Incidental, Asymptomatic Lesions Discovered During Culprit Vessel Coronary Intervention

*NHLBI Registry. 3747 pts 1997-99. 1-yr f/u
216 pts (5.8%) non-target PCI,
mean f/u 163 ± 99 days*

✧ 86.9% of lesions requiring repeat PCI ≤ 60%
at original study

✧ Lesions < 50% at initial angio 60.5%

✧ Lesions > 70% at initial angio 13.4%

✧ MVD at original angio 76.4%

Clinical Progression of Incidental, Asymptomatic Lesions Discovered During Culprit Vessel Coronary Intervention

✧ Progression in same artery 39%

✧ Progression in different artery 61%

✧ Clinical Presentation:

Acute Coronary Syndrome 68.5%

Stable Angina 24.1%

Atypical Symptoms 6.8%

**Angiographic Prediction
of Vulnerable Plaque
Is Not Accurate**

PROSPECT Study

PI, Dr. Gregg Stone, Guidant, Volcano
3-vessel imaging post PCI of culprit lesion
IVUS

Virtual Histology



F/U: 1 mo, 6 mo, 1 yr, 2 yr, \pm 3-5 yr
(event driven)



Meds recommended:
Aspirin, Plavix 1yr, Statin



Repeat imaging
in pts with events

Patients enrolled as of 4/5/06 = 639 (from MAHI = 38)



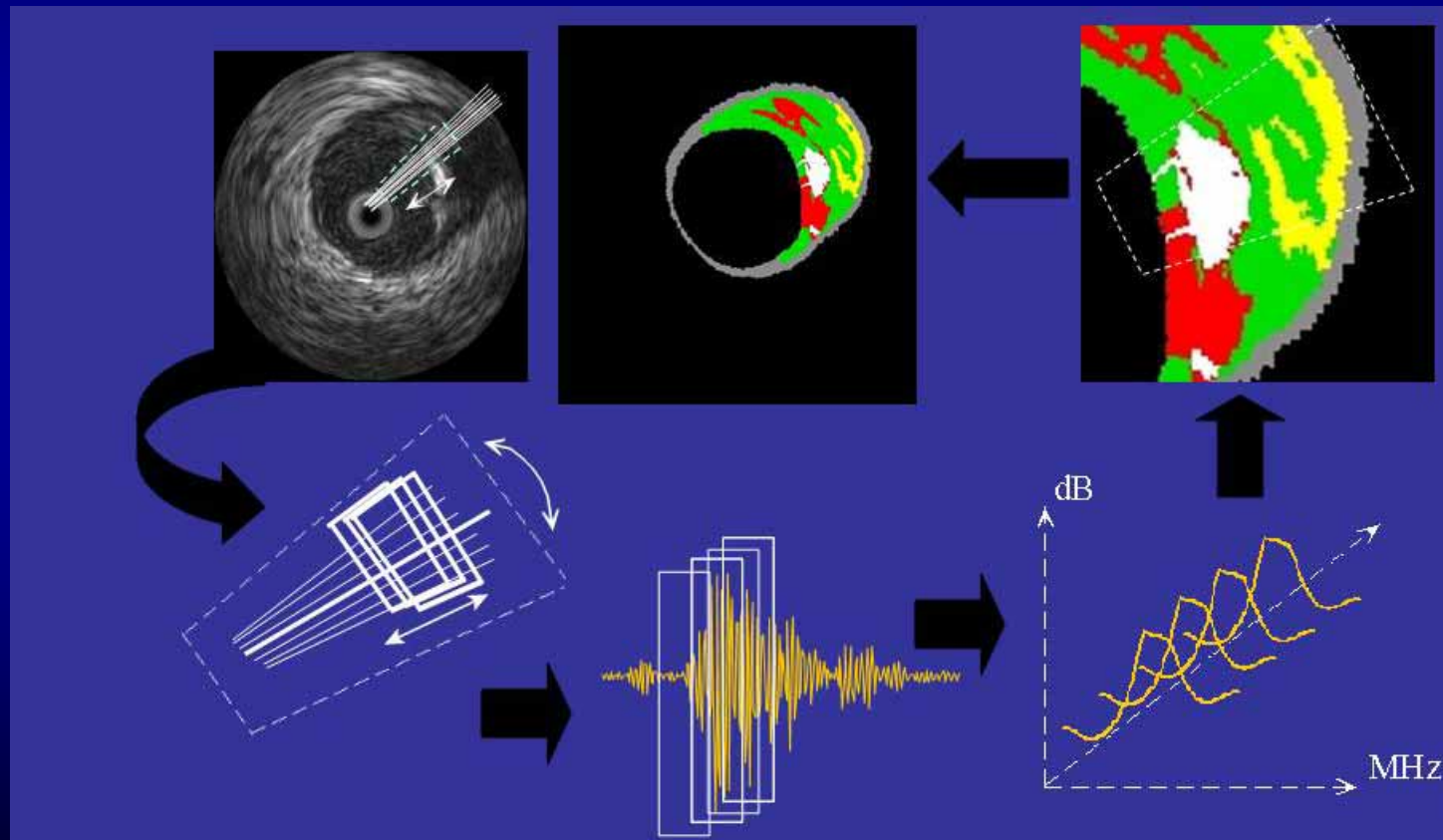
What is Virtual Histology?

- ✧ **Real-time plaque characterization and visualization with spectral analysis of intravascular ultrasound data**
- ✧ **Spectral analysis of the backscattered radiofrequency ultrasound signals allows detailed assessment of plaque composition**

Image Interpretation

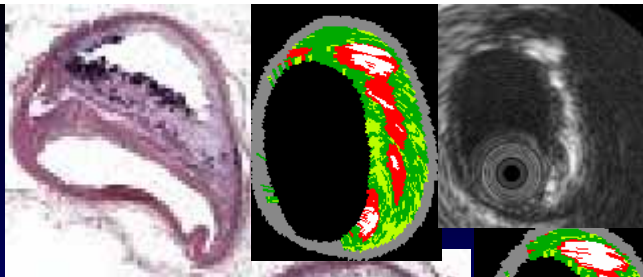
The *Volcano IVUS* Program

- ☆ In-vivo characterization of plaque composition via advanced spectral analysis

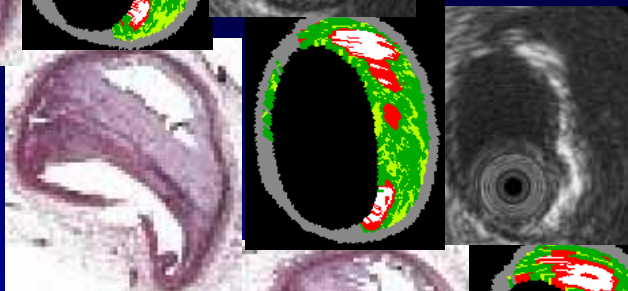


Fibrous; Fibro-lipidic; Lipidic-necrotic; Calcium

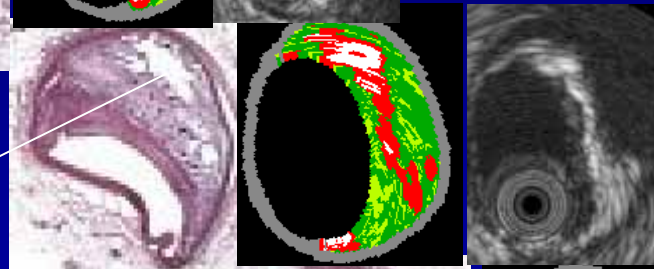
In Vitro Histology VS Ex Vivo Plaque Composition



83

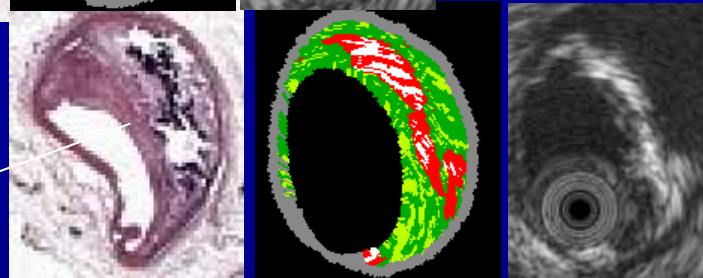


85



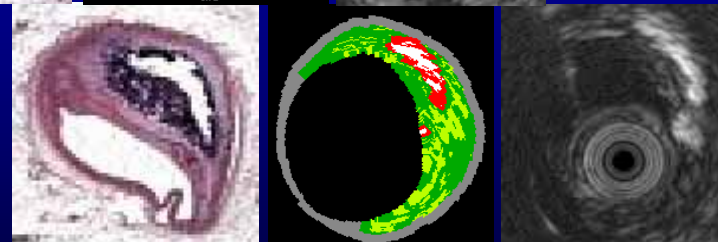
87

Calcified, lipid
necrotic core

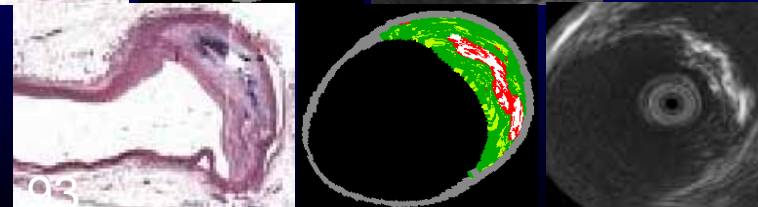


88

Fibrotic cap
about 400 μm



91



93

EAGLE EYE JUNE 2005

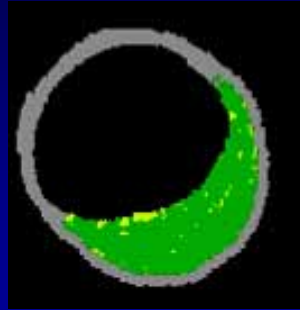
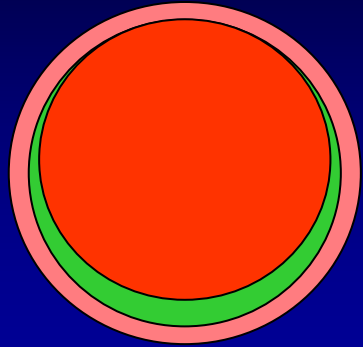
CLASSIFICATION TREE Accuracy Data:

Slice by Slice VH & Histology Comparison

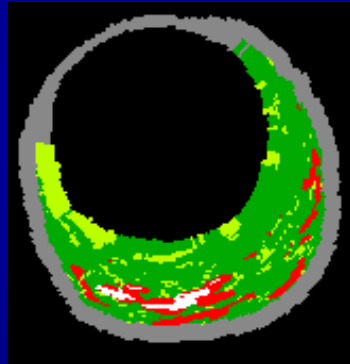
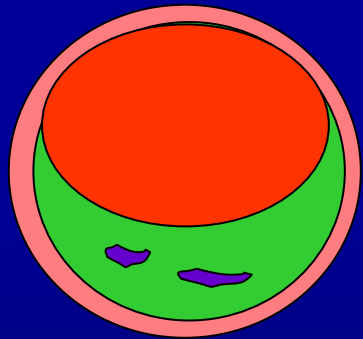
- ✧ Overall accuracy for ROIs – 94.96%
- ✧ 51 LADs, 115 Artery Sites, 407 Total ROIs

	Sensitivity	Specificity	Predictive Accuracy
	(%)	(%)	(%)
Fibrous Tissue (<i>n</i> = 162)	83.95	98.78	92.87
Fibro Fatty (<i>n</i> = 84)	86.90	95.05	93.37
Necrotic Core (<i>n</i> = 69)	97.10	93.79	94.35
Dense Calcium (<i>n</i> = 92)	97.83	99.68	99.26

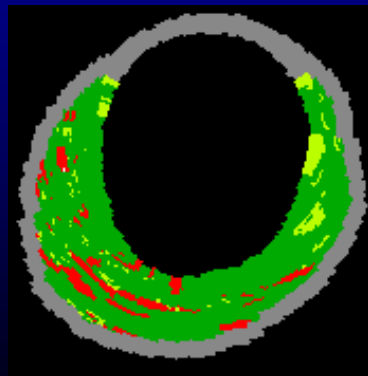
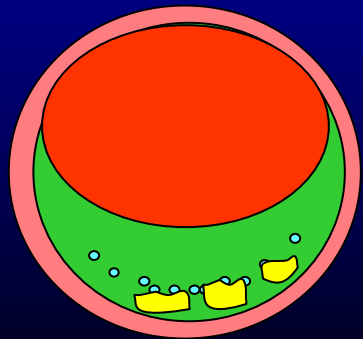
Generally Stable Plaque Types*



“Fibrous” – Plaque nearly all fibrous tissue.



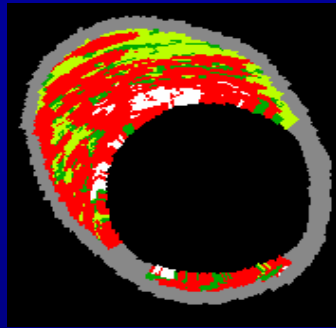
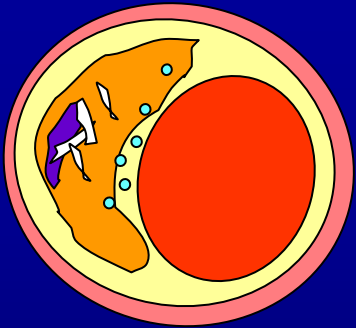
“Fibro-Calcific” – Mainly fibrous with some Dense Calcium. Necrotic Core 3-10%



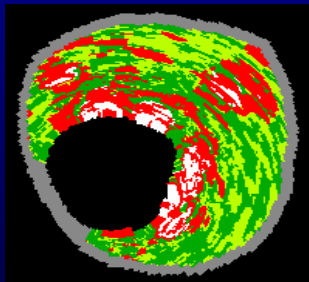
“Pathological Intimal Thickening” –Fibro-Fatty and Fibrous tissue, with Necrotic Core 0-3% due to micro-calcifications within the Fibro-Fatty tissue. Possible progression to risky atheroma.

**Courtesy of Renu Virmani*

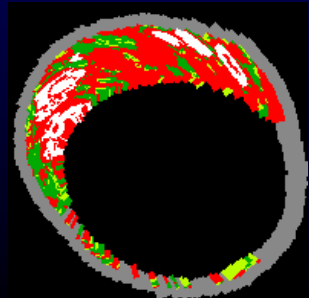
Thin-Cap FibroAtheroma (TCFA)



“Thin Cap Fibro-Atheroma (TCFA)” or **“Vulnerable Plaque”** - Necrotic Core $>10\%$ of total plaque volume *and* located at or near the lumen.



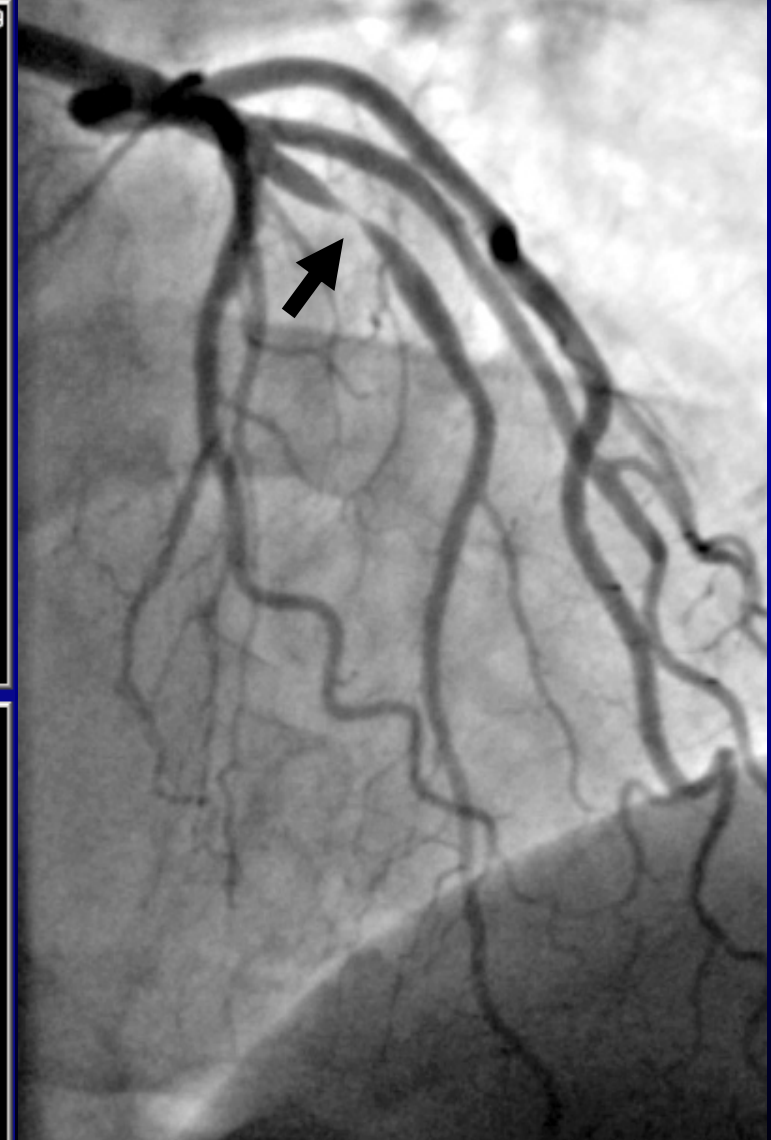
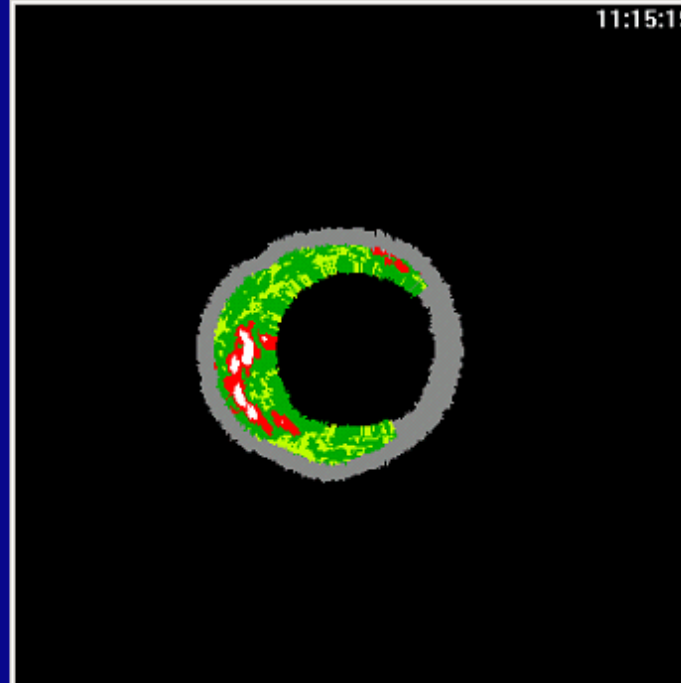
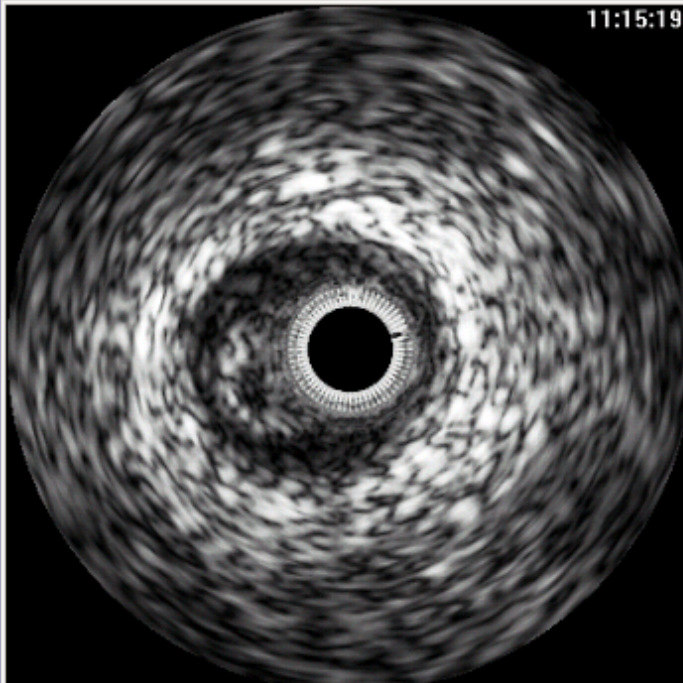
“TCFA with significant narrowing” ($\geq 50\%$ reduction in Cross Sectional Area on IVUS or $DS \geq 25\%$ on angiogram)



“TCFA without significant narrowing” ($< 50\%$ area reduction on IVUS or $< 25\%$ DS on angiogram)



53-Year-Old Male Acute Non-STEMI



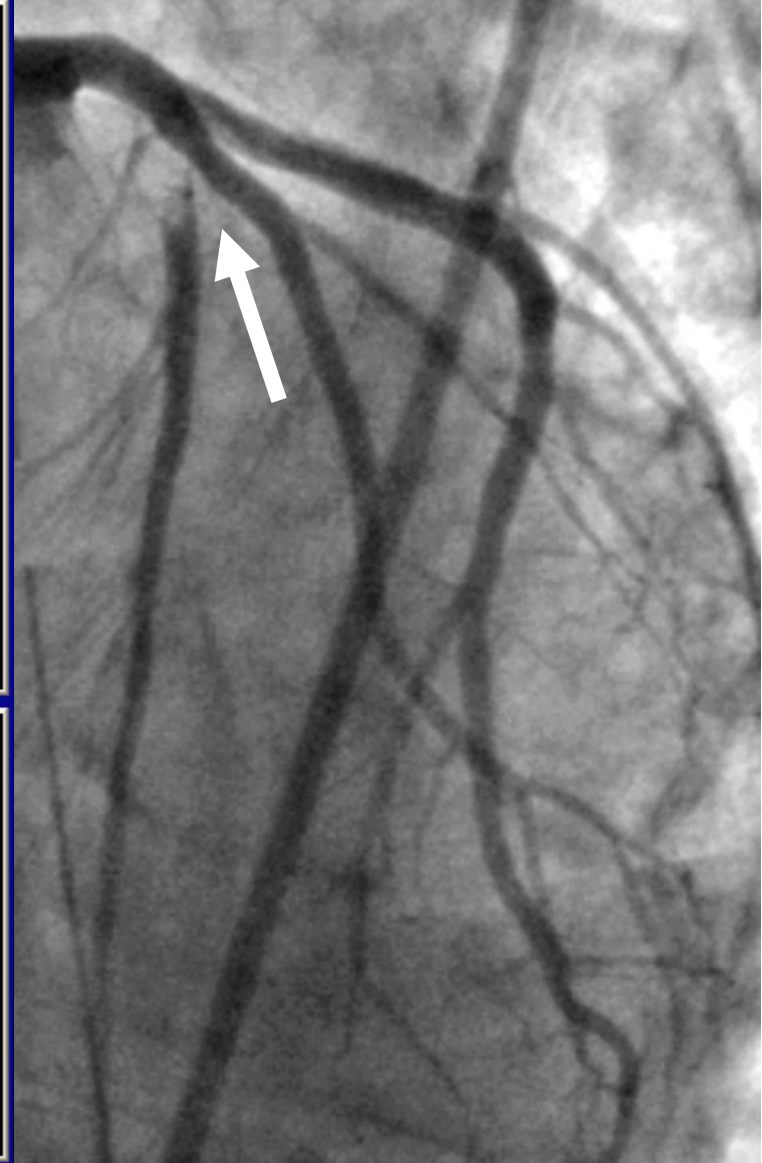
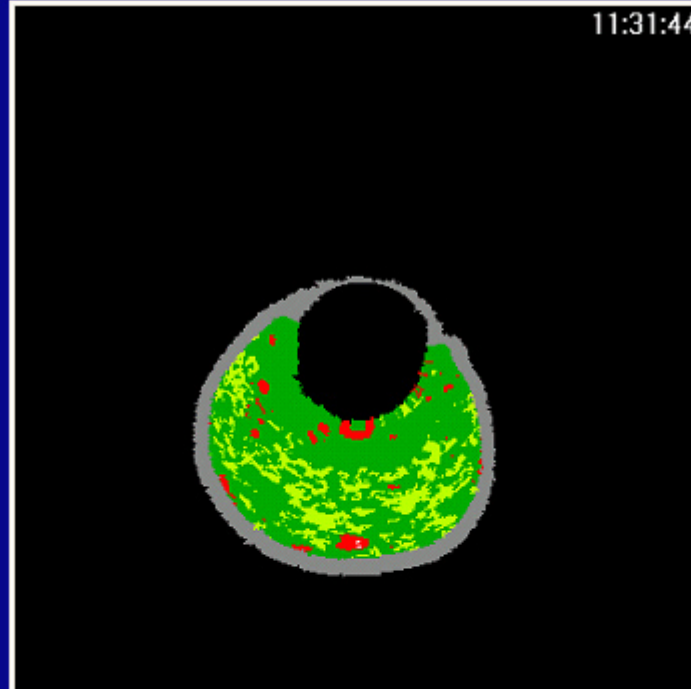
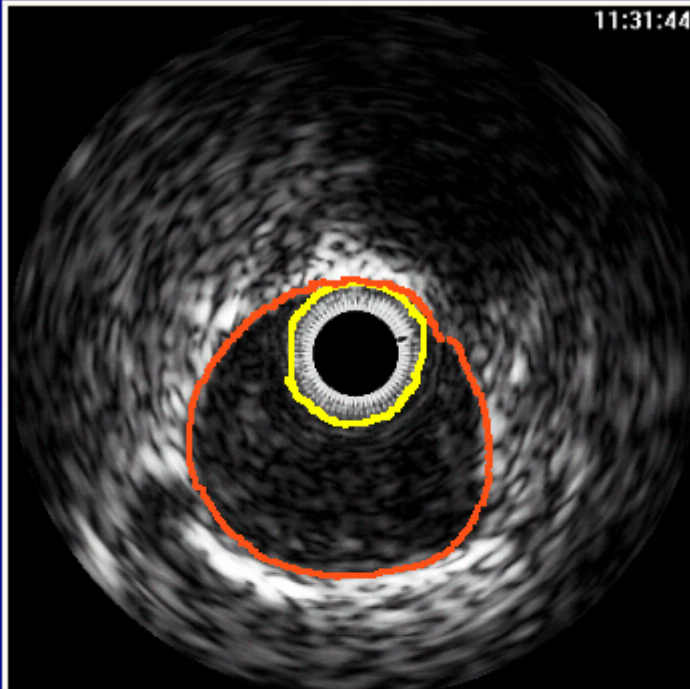
Lumen Area	4.3 mm ²	
EEL Area	11.4 mm ²	
Plaque Area	7.0 mm ²	
% Plaque Burden	62 %	
Fibrous Area	2.4 mm²	62 %
Fibro-Fatty Area	0.8 mm²	21 %
Dense Calcium Area	0.2 mm ²	4 %
Necrotic Core Area	0.5 mm²	13 %

More ...





53-Year-Old Male Acute Anterior Infarct



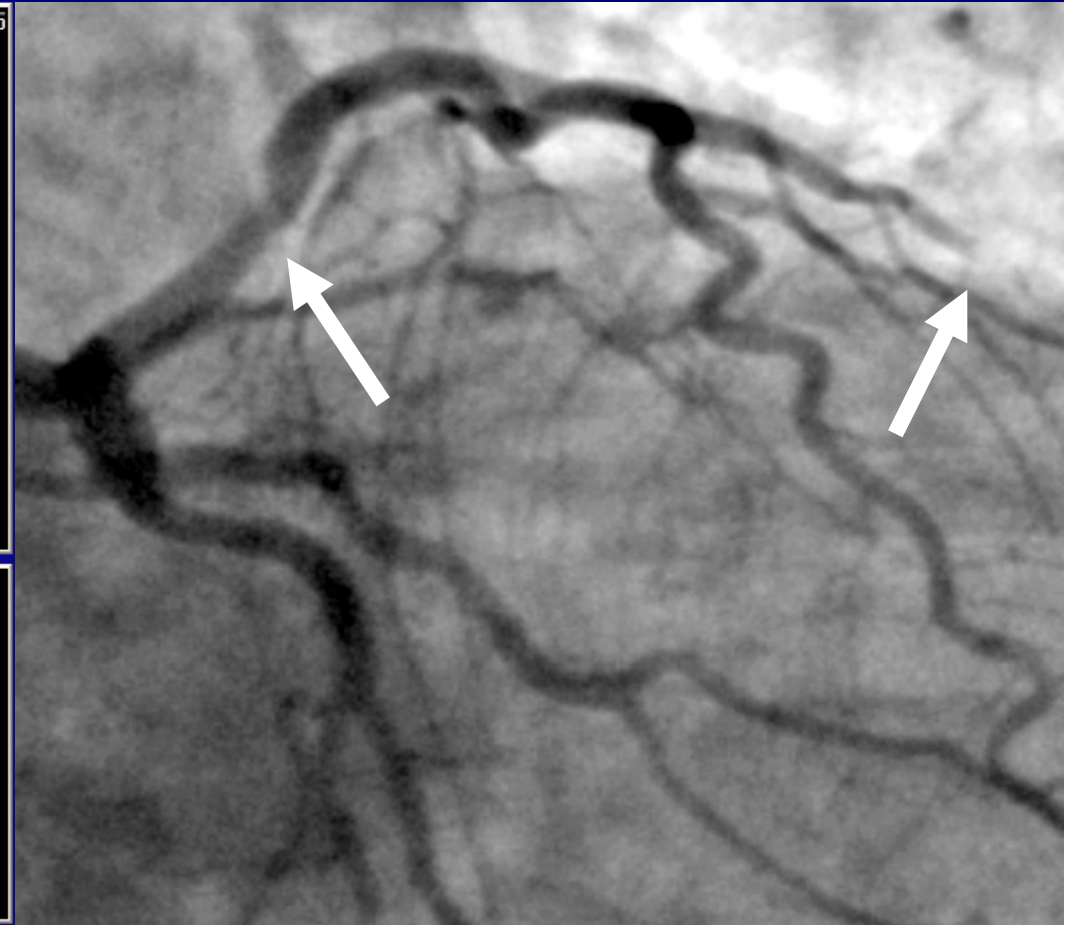
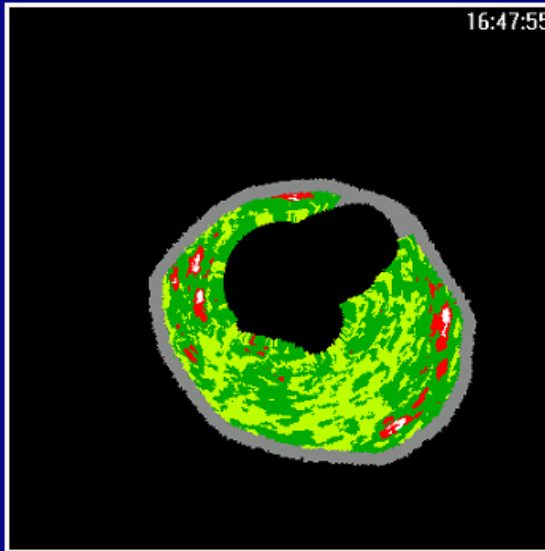
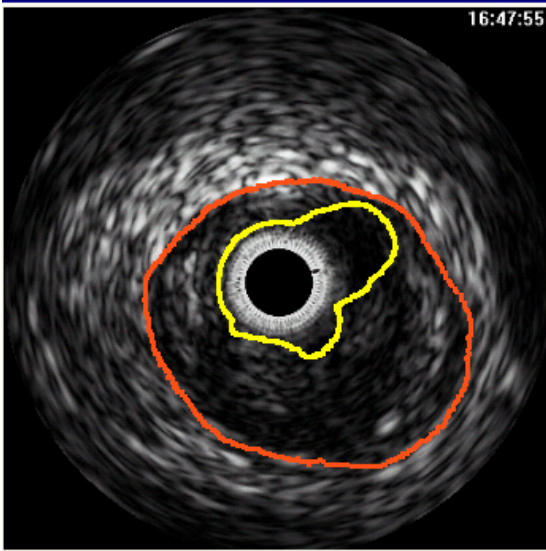
Lumen Area	3.1 mm ²	
EEL Area	15.0 mm ²	
Plaque Area	11.9 mm ²	
% Plaque Burden	79 %	
Fibrous Area	6.8 mm ²	75 %
Fibro-Fatty Area	1.8 mm ²	20 %
Dense Calcium Area	0.0 mm ²	0 %
Necrotic Core Area	0.4 mm ²	4 %

More ...





58-Year-Old Male Acute Lateral Wall Infarct



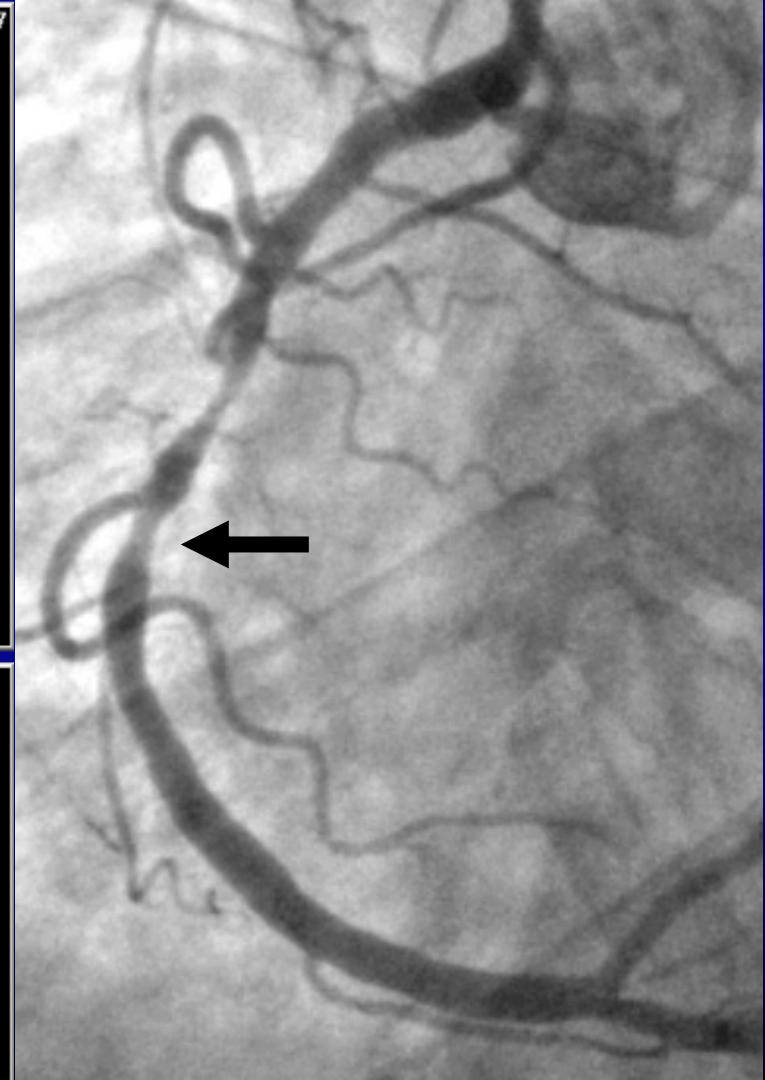
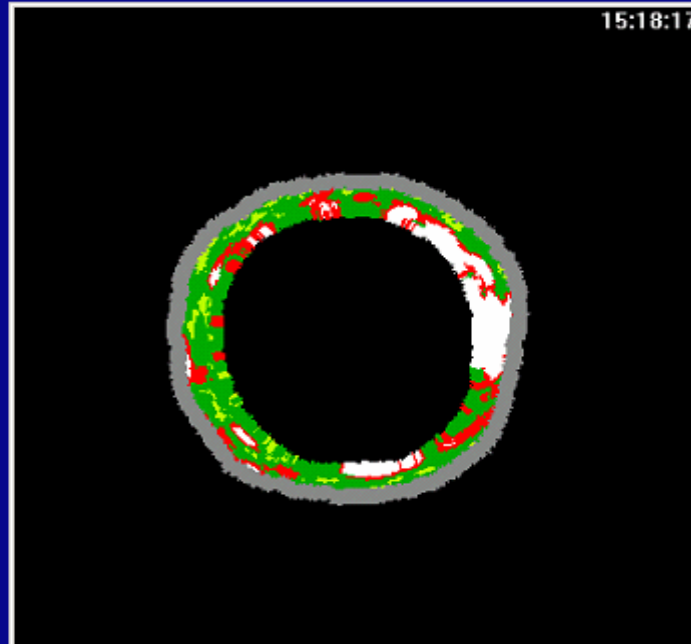
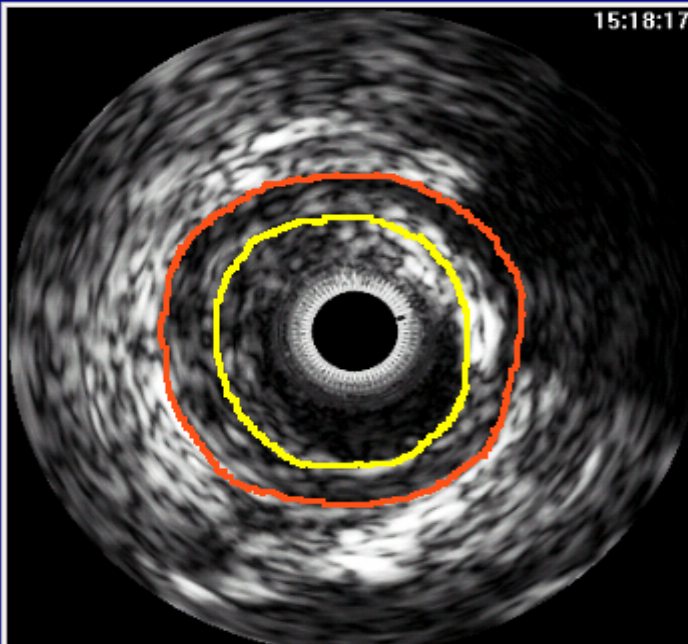
Lumen Area	6.0 mm ²	
EEL Area	24.5 mm ²	
Plaque Area	18.5 mm ²	
% Plaque Burden	76 %	
Fibrous Area	8.2 mm ²	57 %
Fibro-Fatty Area	5.2 mm ²	36 %
Dense Calcium Area	0.1 mm ²	1 %
Necrotic Core Area	0.8 mm ²	6 %

More ...





52-Year-Old Male Acute Inferior Infarct



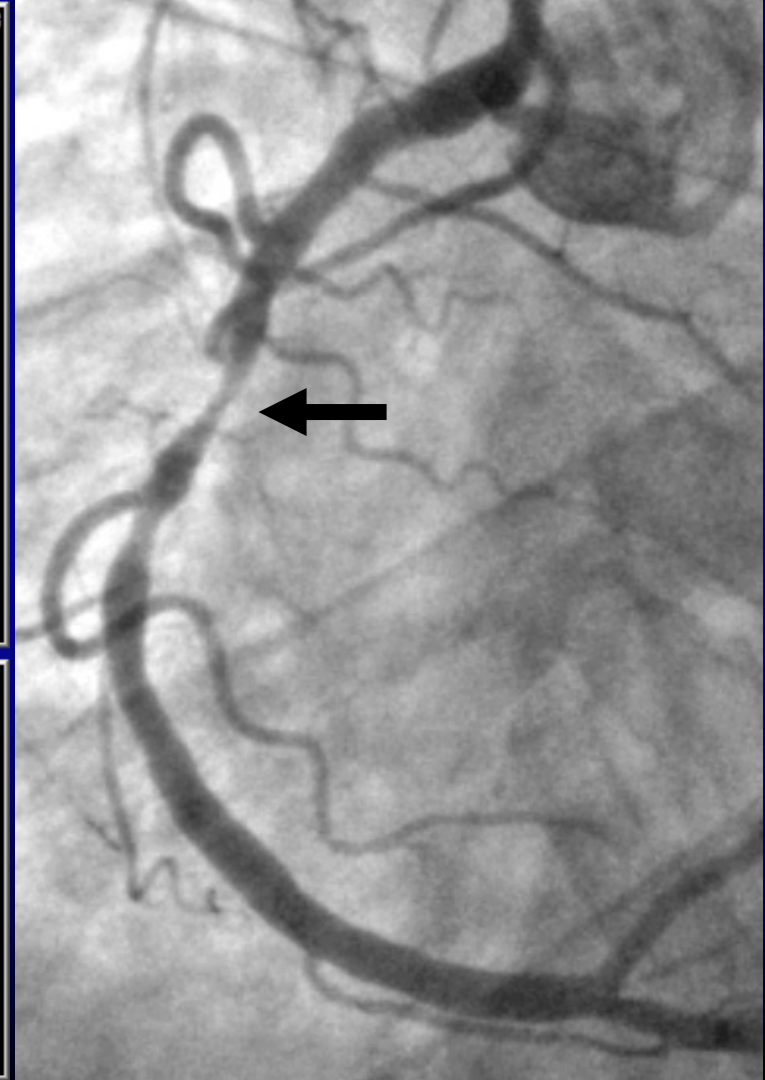
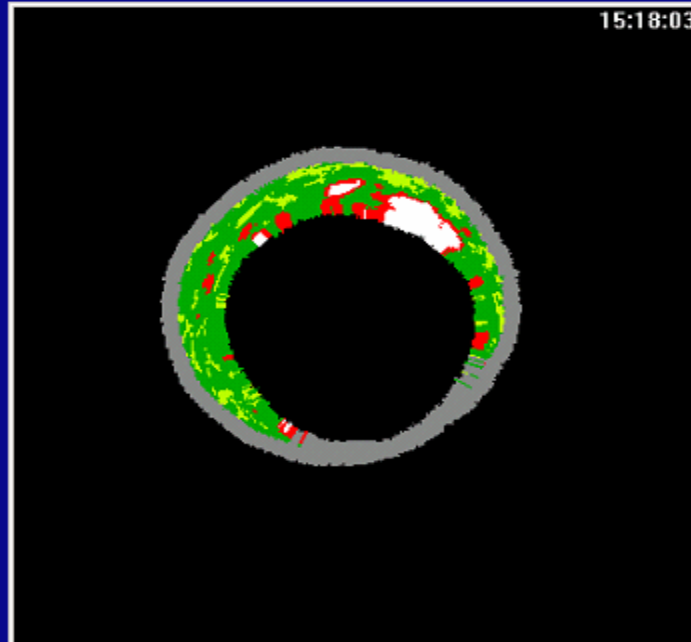
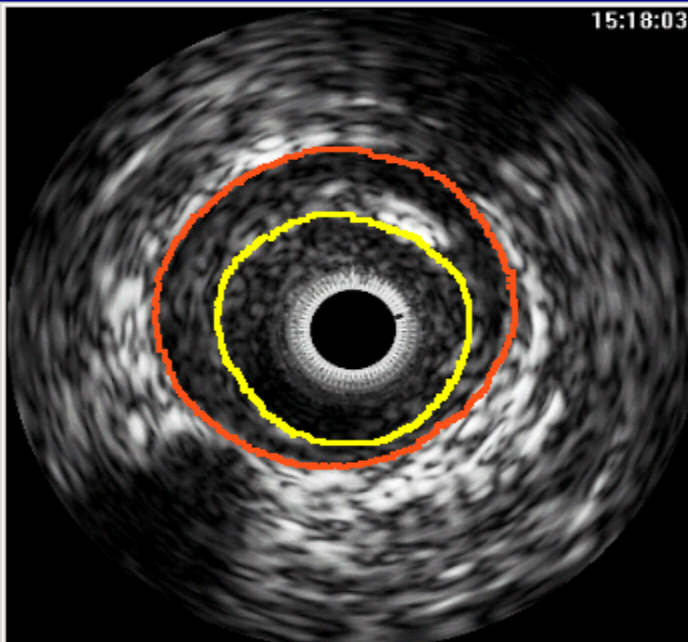
Lumen Area	11.5 mm ²	
EEL Area	22.2 mm ²	
Plaque Area	10.6 mm ²	
% Plaque Burden	48 %	
Fibrous Area	3.4 mm ²	51 %
Fibro-Fatty Area	0.5 mm ²	7 %
Dense Calcium Area	1.5 mm ²	23 %
Necrotic Core Area	1.3 mm ²	19 %

More ...





52-Year-Old Male Acute Inferior Infarct



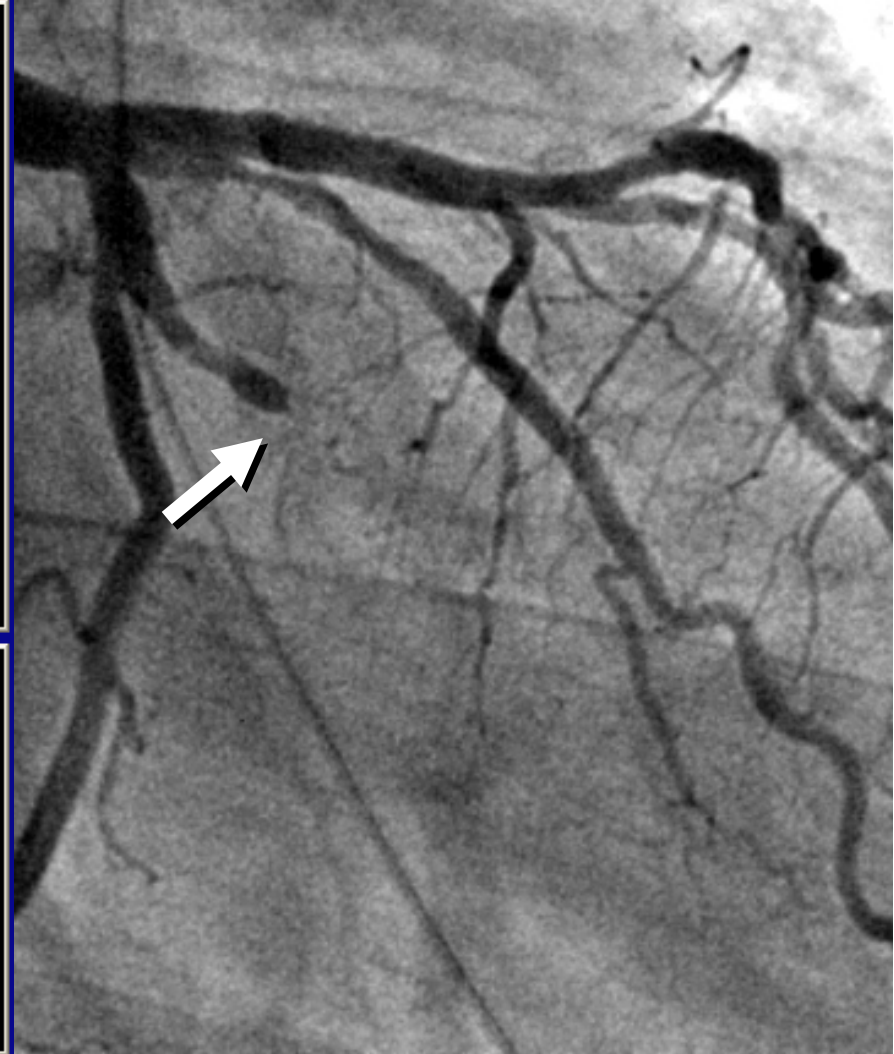
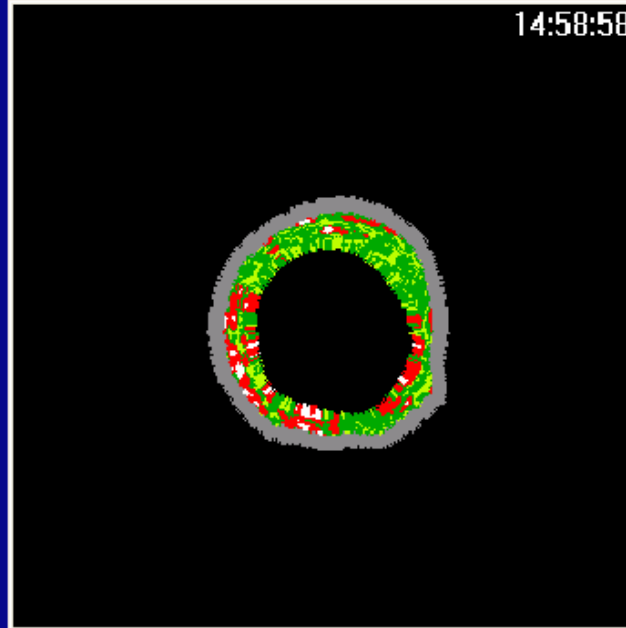
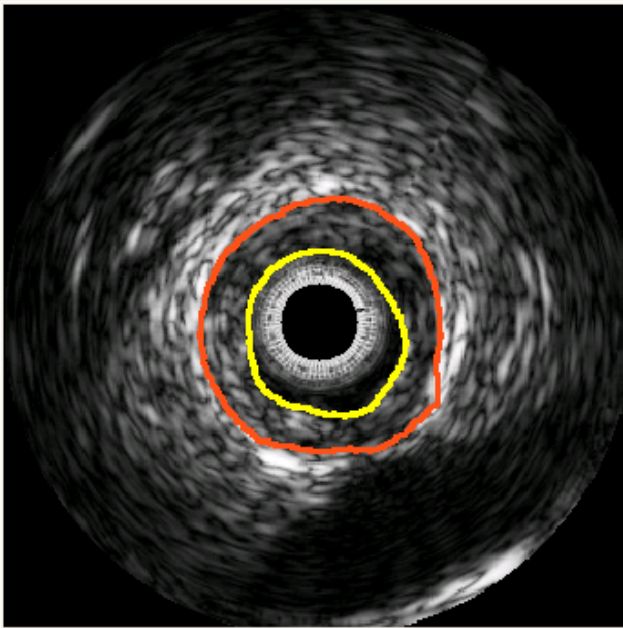
Lumen Area	10.1 mm ²	
EEL Area	20.3 mm ²	
Plaque Area	10.2 mm ²	
% Plaque Burden	50 %	
Fibrous Area	3.9 mm ²	64 %
Fibro-Fatty Area	0.8 mm ²	14 %
Dense Calcium Area	0.6 mm ²	10 %
Necrotic Core Area	0.7 mm ²	12 %

More ...





65-Year-Old Male Acute Inferior STEMI (LB)



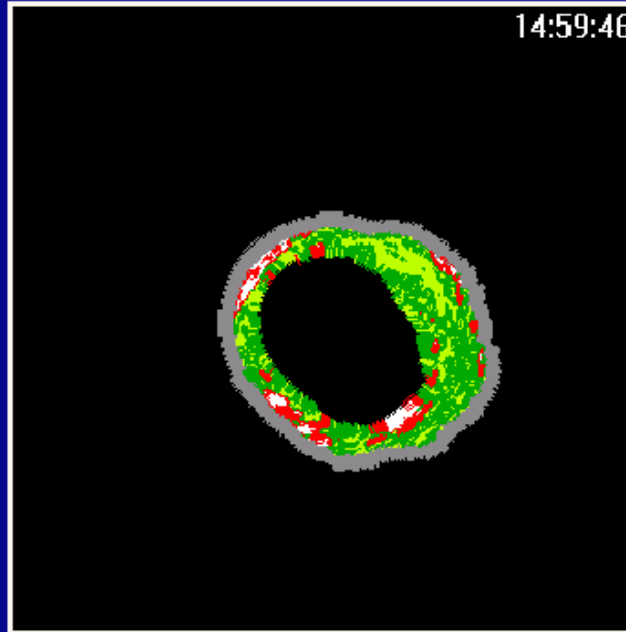
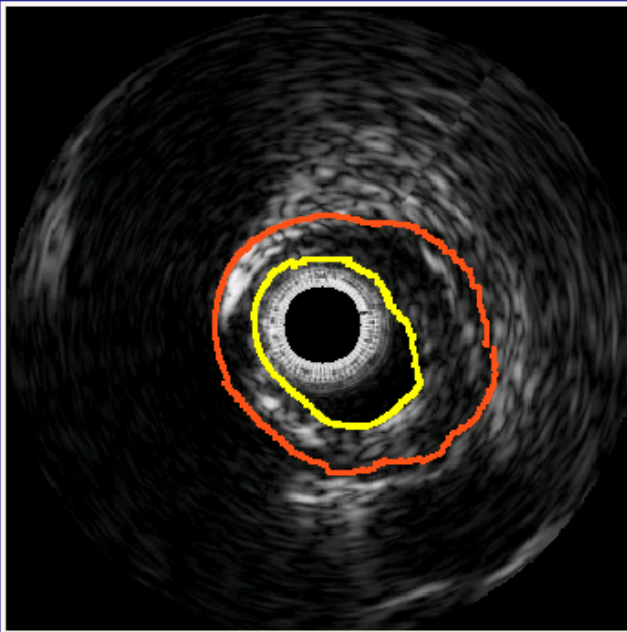
Lumen Area	5.2 mm ²	
EEL Area	12.9 mm ²	
Plaque Area	7.7 mm ²	
% Plaque Burden	60 %	
Fibrous Area	2.5 mm ²	52 %
Fibro-Fatty Area	0.9 mm ²	19 %
Dense Calcium Area	0.2 mm ²	5 %
Necrotic Core Area	1.1 mm ²	23 %

More ...





65-Year-Old Male Acute Inferior STEMI (LB)



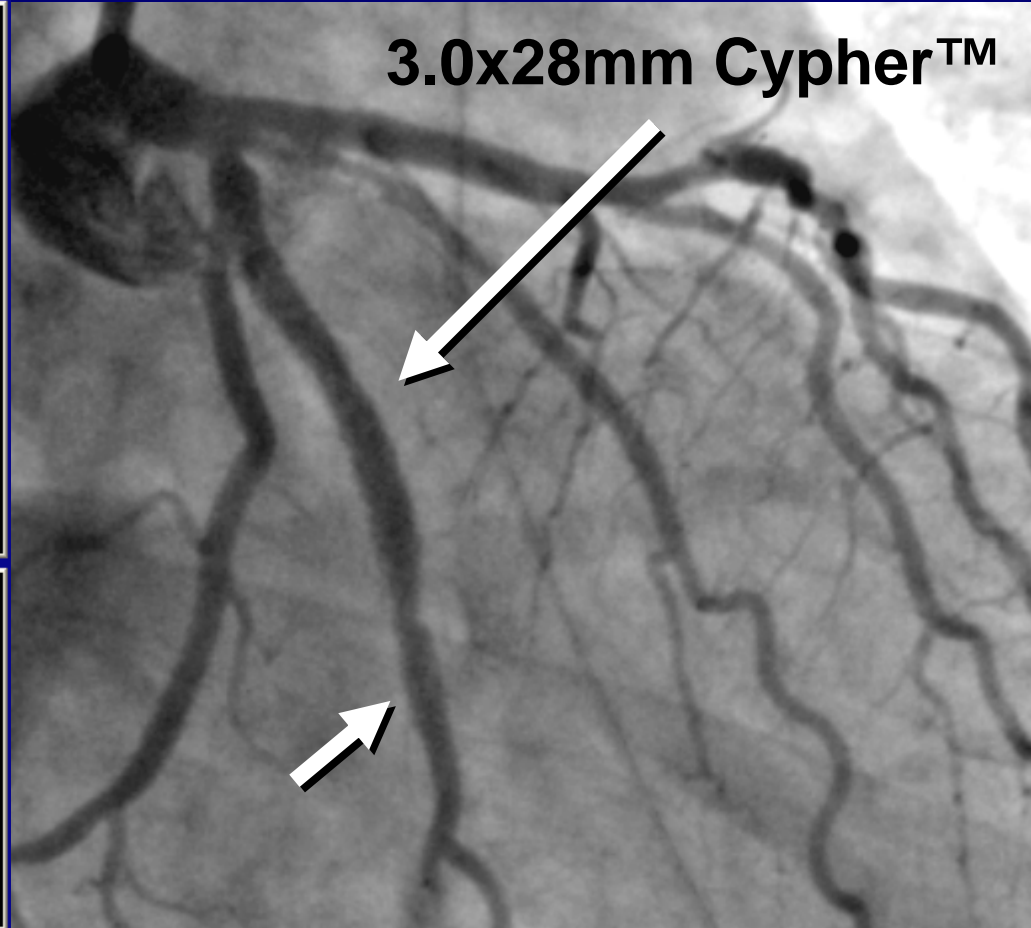
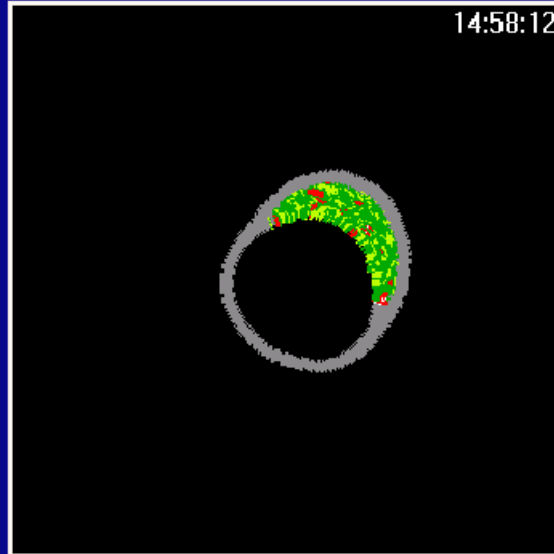
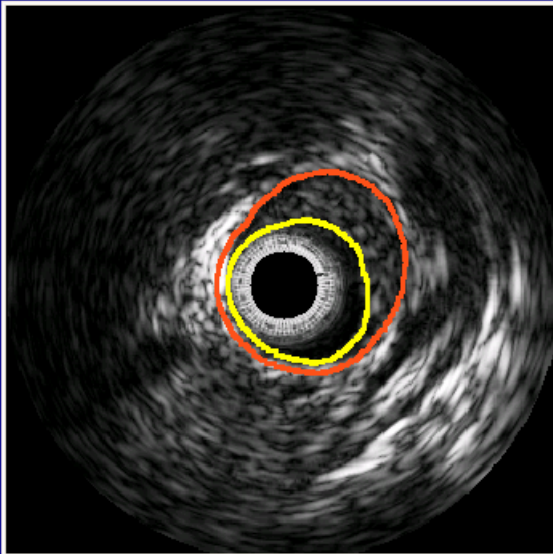
Lumen Area	5.2 mm ²	
EEL Area	14.6 mm ²	
Plaque Area	9.4 mm ²	
% Plaque Burden	64 %	
Fibrous Area	3.6 mm ²	57 %
Fibro-Fatty Area	1.5 mm ²	23 %
Dense Calcium Area	0.4 mm ²	6 %
Necrotic Core Area	0.9 mm ²	15 %

More ...

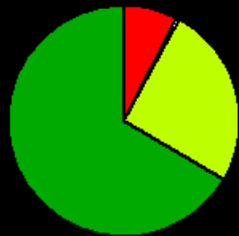




65-Year-Old Male Acute Inferior STEMI (LB)

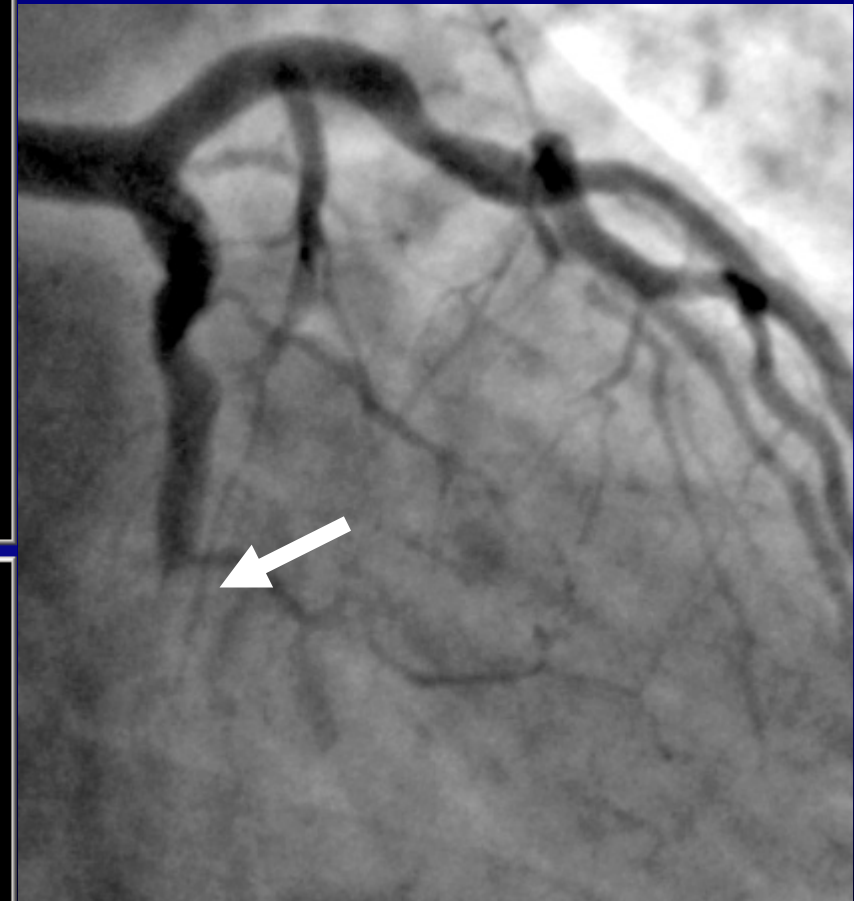
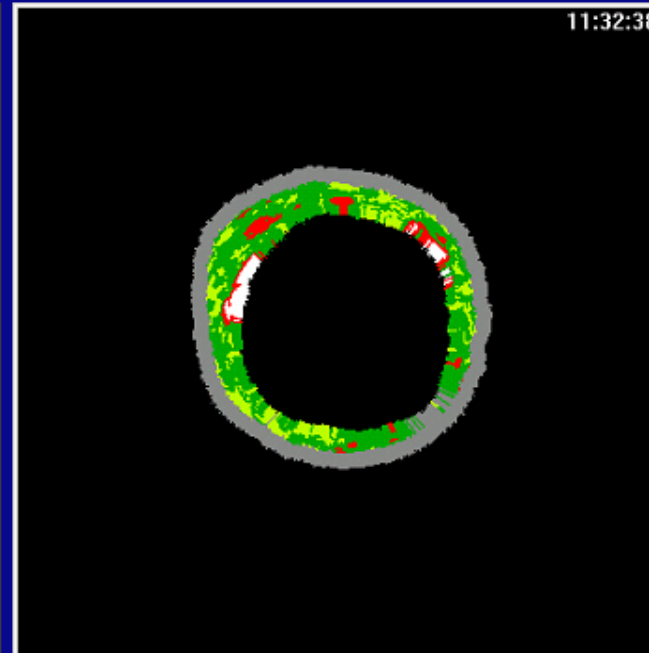
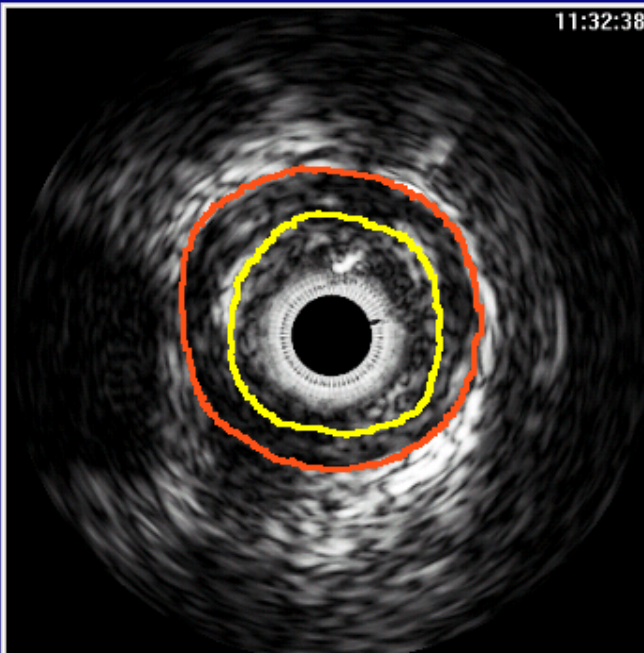


Lumen Area	5.2 mm ²	
EEL Area	9.7 mm ²	
Plaque Area	4.6 mm ²	
% Plaque Burden	47 %	
Fibrous Area	1.4 mm ²	66 %
Fibro-Fatty Area	0.5 mm ²	25 %
Dense Calcium Area	0.0 mm ²	0 %
Necrotic Core Area	0.2 mm ²	8 %





63-Year-Old Male Acute Inferior Wall Infarct – LCX IRA



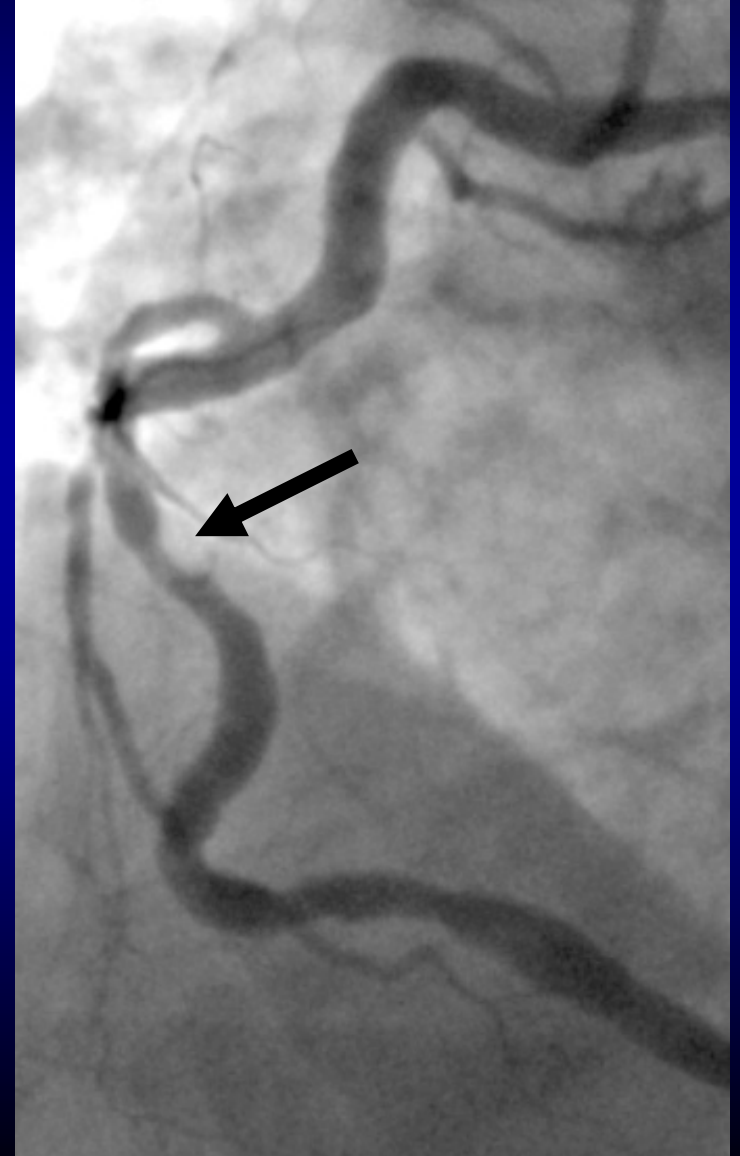
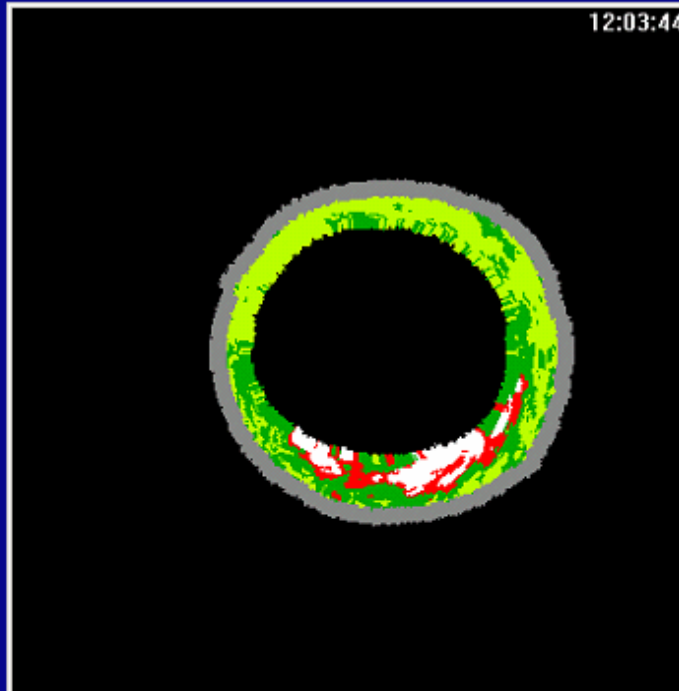
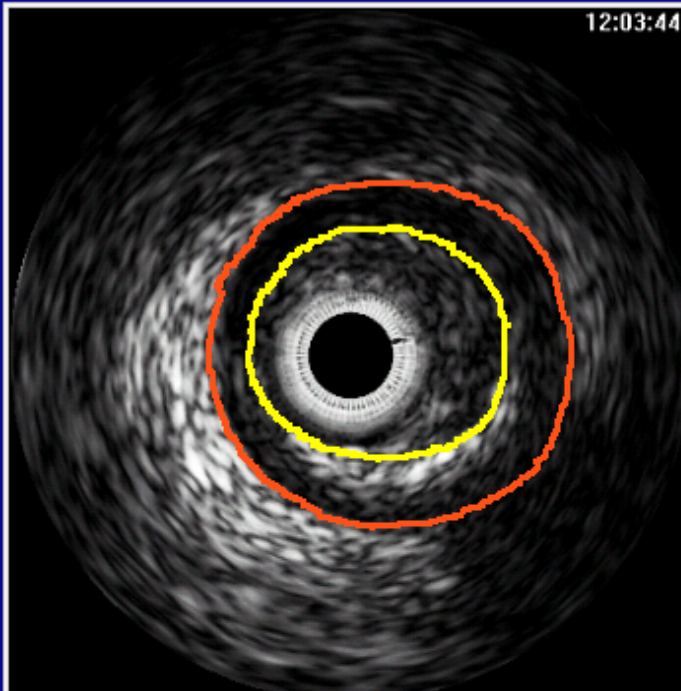
Lumen Area	8.9 mm ²	
EEL Area	17.6 mm ²	
Plaque Area	8.7 mm ²	
% Plaque Burden	50 %	
Fibrous Area	3.2 mm ²	63 %
Fibro-Fatty Area	1.1 mm ²	21 %
Dense Calcium Area	0.3 mm ²	6 %
Necrotic Core Area	0.5 mm ²	9 %

More ...





63-Year-Old Male Acute Inferior Wall Infarct - RCA



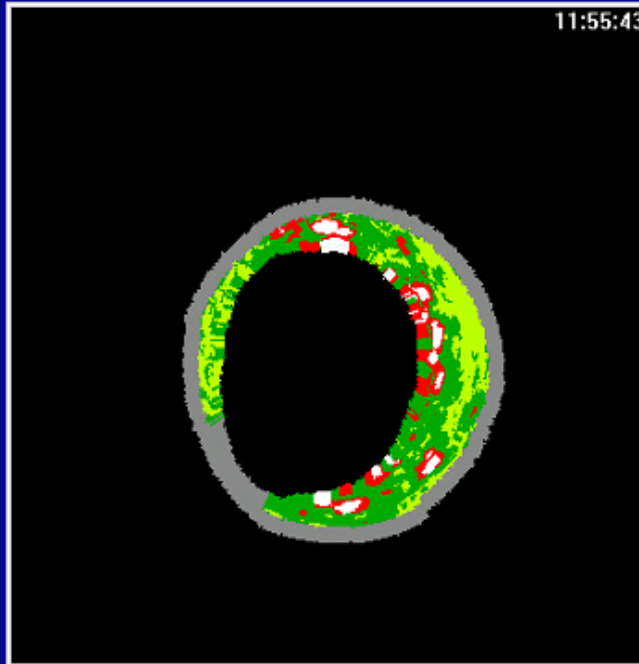
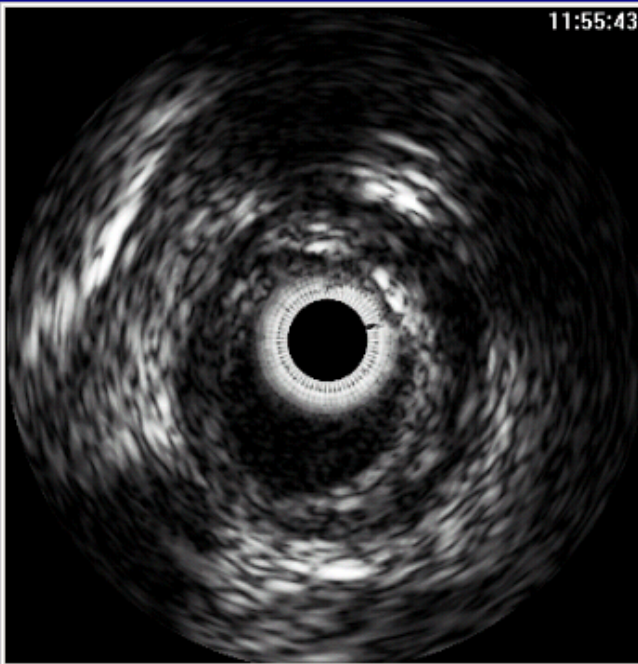
Lumen Area	10.1 mm ²	
EEL Area	21.7 mm ²	
Plaque Area	11.6 mm ²	
% Plaque Burden	54 %	
Fibrous Area	2.8 mm ²	36 %
Fibro-Fatty Area	3.4 mm ²	44 %
Dense Calcium Area	0.8 mm ²	11 %
Necrotic Core Area	0.7 mm ²	9 %

More ...





63-Year-Old Male Acute Inferior Wall Infarct - LAD



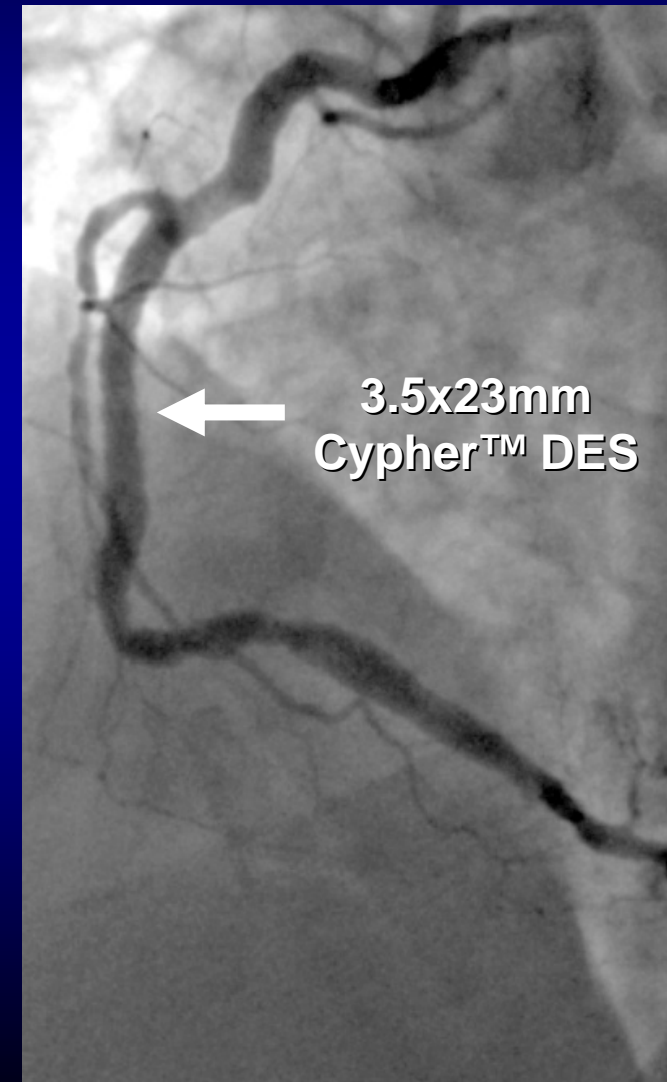
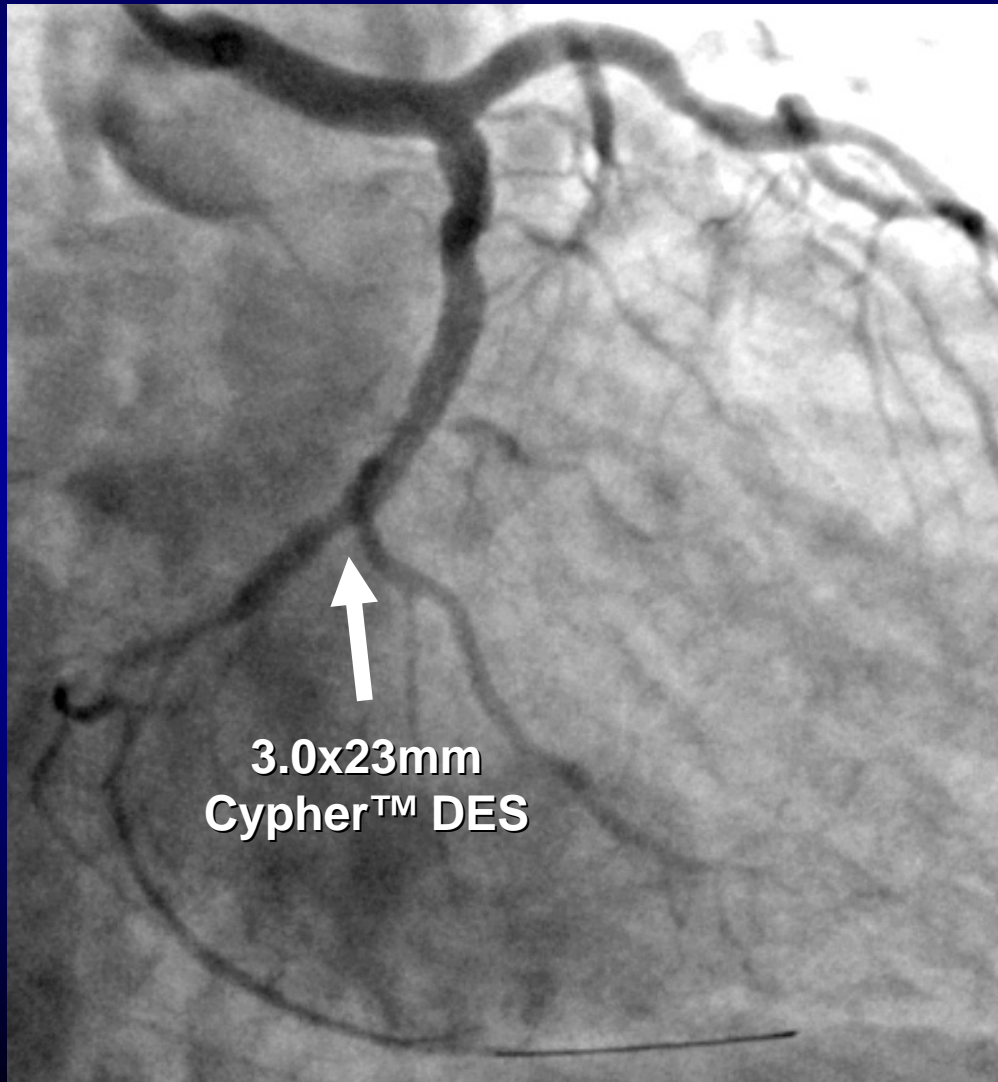
Lumen Area	9.5 mm ²	
EEL Area	20.9 mm ²	
Plaque Area	11.5 mm ²	
% Plaque Burden	55 %	
Fibrous Area	3.9 mm ²	52 %
Fibro-Fatty Area	2.0 mm ²	27 %
Dense Calcium Area	0.6 mm ²	8 %
Necrotic Core Area	1.0 mm ²	13 %

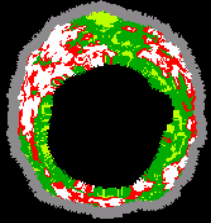
More ...





63-Year-Old Male Acute Inferior Wall Infarct





Virtual Histology in AMI

- ☆ Good characterization and visualization of plaque composition & volume (plaque burden)
- ☆ Careful border recognition to exclude thrombus
- ☆ Surprisingly widespread distribution of vulnerable plaques in pts with ACS – relating to both culprit and non-culprit arteries

“Systemic Vascular Illness”



IVUS-VH Derived Plaque Phenotyping

Mid America Heart Institute

- ☆ **IVUS-VH imaging in 76 pts prior to PCI
209 lesions of interest evaluated**
- ☆ **20 MHz catheter (Eagle Eye, Volcano Corp,
CA) Automated pullback 0.5 mm/second**
- ☆ **Utilizing a latent class cluster technique, 3
unique phenotypes were identified**

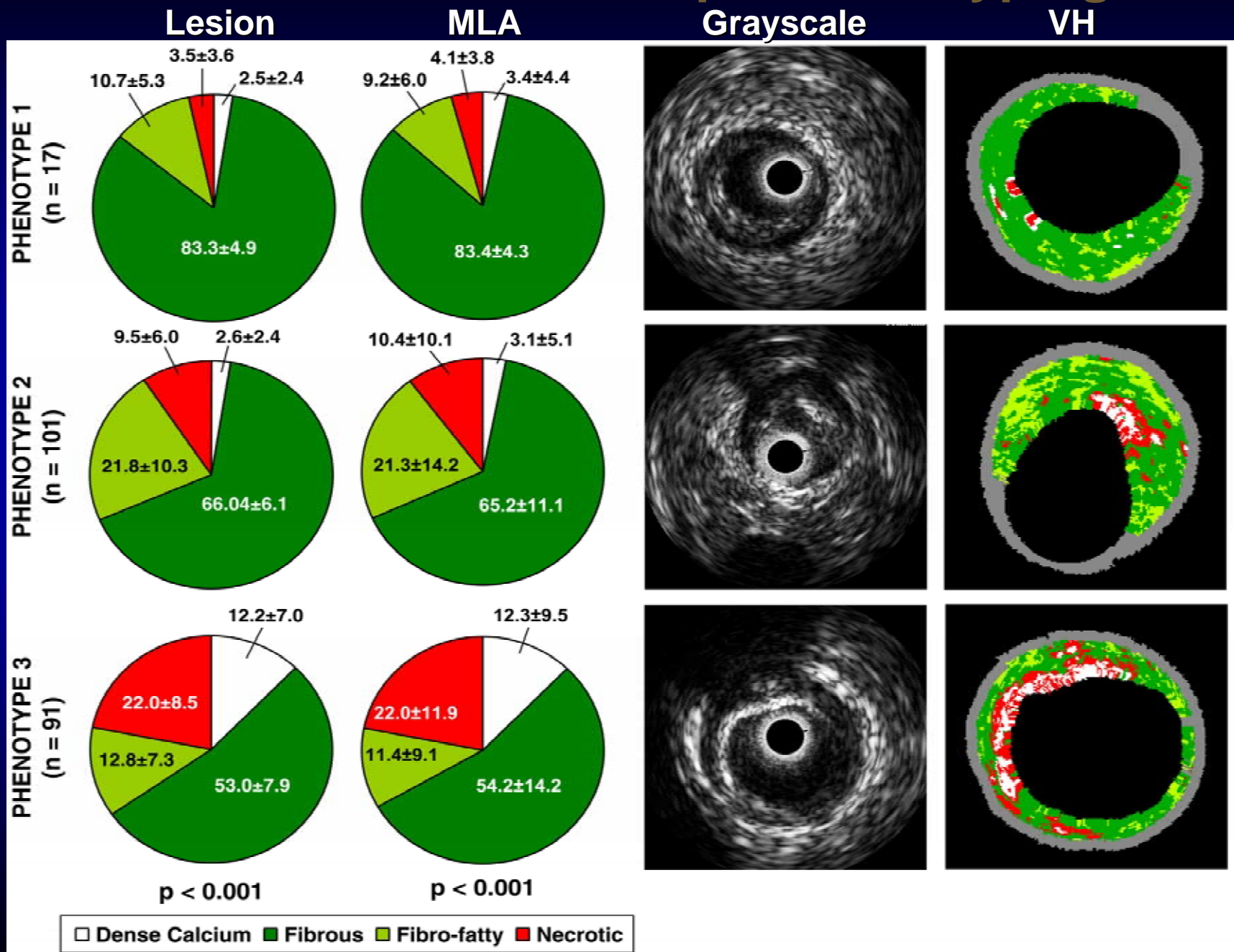


IVUS-VH Derived Plaque Phenotyping

	Phenotype 1 (n=17)	Phenotype 2 (n=101)	Phenotype 3 (n=91)	P-value
Segment length (mm)	16.79 ± 12.33	15.06 ± 9.62	17.51 ± 10.55	0.03
Seg vol plaque burden (mm ³)	43.66 ± 6.91	46.41 ± 11.53	50.93 ± 10.31	0.003
MLA plaque burden (%)	52.58 ± 9.82	55.96 ± 14.75	61.48 ± 12.38	0.004
Stenosis at MLA (%)	24.93 ± 19.59	31.28 ± 18.27	37.52 ± 16.97	0.007
MLA vessel EEL CSA (mm ²)	11.13 ± 5.27	15.42 ± 5.85	14.33 ± 4.91	0.009
MLA vessel min diam (mm)	3.42 ± 0.83	4.03 ± 0.80	3.88 ± 0.70	0.009
MLA lumen CSA (mm ²)	5.09 ± 2.23	6.64 ± 3.55	5.35 ± 2.30	0.006
MLA plaque CSA (mm ²)	6.03 ± 3.43	8.78 ± 4.43	8.98 ± 4.05	0.03
Remodeling index at MLA	0.96 ± 0.17	0.94 ± 0.15	0.92 ± 0.16	0.6
Eccentricity	0.43 ± 0.20	0.58 ± 0.19	0.58 ± 0.17	0.06



IVUS-VH Derived Plaque Phenotyping





IVUS-VH Derived Plaque Phenotyping

Conclusions:

- ✧ IVUS-VH is a feasible imaging platform to define lesions in target vessels of PCI patients
- ✧ There were 1.5 non-culprit lesions for every 1 culprit lesion in target vessels
- ✧ Identified 3 distinct phenotypes that differed with respect to composition and plaque burden ($p < 0.001$)
- ✧ Tight correlation between lesion phenotype and mean lumen area plaque composition ($p < 0.001$)



IVUS-VH Derived Plaque Phenotyping

Conclusions:

☆ Among pts with > one lesion:

- 34 (46%) had lesions of single phenotype
- 37 (50%) had lesions of two phenotypes
- 3 (4%) had lesions of three phenotypes

☆ Trend for clustering of culprit plaques to phenotypes 2 and 3 ($p = 0.077$)